Hand in Traffic Lab (not the unit conversion sheet)

Measurement Accuracy and Precision
- Percent Error and Significant Figures
- Worksheet

get textbooks from bookroom
set up seating plan

Next class - labs and graphing

Quiz September 25th

Measurement Accuracy and Precision:

Accuracy - How close is your measurement or calculated value to the "actual" value.

Quantify accuracy by comparing experimental value to a theoretical value.

experimental error or %error
%error = |experimental-theoretical|/theoretical x100

for example, you look up the density of aluminum to be 2.70g/cm^3.
You measure the mass of a block to be 55.0 g and dimensions of 5.00cm by 2.00 cm by 2.00cm.
What is the

a) experimental density
b) %error ?
c) possible cause of the error?

Density = mass/volume ρ = M/V = M/(LxWxH)

a) 55/(2x5x2)=2.75 g/cm^3 (don't forget units)
b)
%error = |experimental-theoretical|/theoretical x100
= |2.75-2.70|/2.70 x 100 = 1.85% error

c) measuring devices have a limit to your ability to measure perfectly. What is the limit of a ruler? estimate of the uncertainty is half of the smallest unit, so for a rule half of a millimeter. +/- 0.5mm uncertainty.

There may be impurities, water causing oxidation for example, that alters the block.

We can estimate uncertainties and then limit the number of digits of our measurement accordingly.

So, for example, if you use a ruler, you shouldn't measure a length to be 0.5000001cm because the uncertainty is around +/- 0.05cm

you should record 0.500 cm as your measurement

implies that the last digit has uncertainty

So 0.500 can be written in scientific notation as

5.00×10^{-1} cm

this measurement has 3 significant digits.

This implies that the hundredth of a centimeter is uncertain.

rules for sig figs (short for significant figures or significant digits)

Big rule: how many digits when you put it in scientific notation

or

0.0000532 - 5.32×10^{-5} so 3 sig figs

- zeros before a sig fig are not significant

503.2 - 5.032×10^2 4 sig figs
- zeros in between sig figs are significant

50.0 - 5.00×10^1 so it has 3 sig figs

- zeros after a sig fig and after the decimal are significant

500 has 1 significant figure (chem teacher)
500 has unclear precision (physics)

Lab - write in scientific notation to avoid confusion
test - answer to 2 or 3 sig figs even if I forget to write in scientific notation

Rules for multiplying and dividing values:

round your answer to the lowest number of sigfigs of your values.

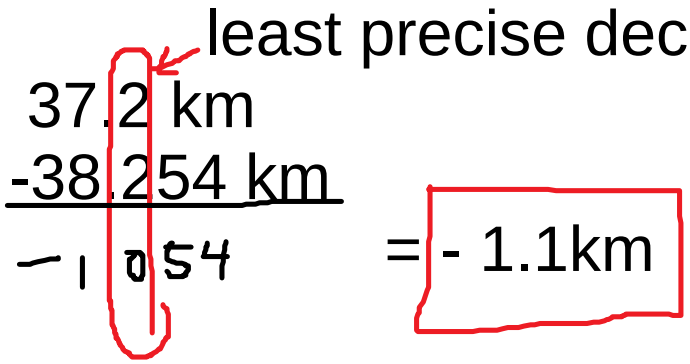
eg. 2.0x 3.51 = 7.02 = 7.0 round to 2 sig figs

Rule for adding and subtracting values:

round your answer to the least precise decimal

place - everything in the same unit and power

eg. 37.2 km - 38 254 m = ?



Block 2-3

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Measurement:

Accuracy and Precision

What is Accuracy?

How close to the "actual" value is the measurement?

Quantify by calculating the error of a quantity or percent error.

%error = (|experimental value-theoretical| /theoretical) x 100

eg. aluminum has a density of 2.70 g/cm^3 (googled it)

You take a block of aluminum and measure the mass to be 55.0g with a length of 5.00cm by 2.00cm by 2.00cm. (electronic balance and rulers)

a) what is the experimental density of the block of aluminum?
b) what is the %error of the experiment?

c) why is there error in this particular experiment.

Density = Mass/Volume ρ=M/V = M/(LxWxH)

a) ρ=M/(LXWXH) = 55/(5x2x2)=2.75 g/cm^3

b)

%error = (|experimental value-theoretical| /theoretical) x 100

= (2.75-2.70)/2.70=0.0185 x100= 1.85%

c) the source of the theoretical value may be wrong - unlikely

Precision - when you repeat measurements, there is a range of values for the same measurement because of the limits of the measuring device or your use of the device. The last digit of any measurement includes uncertainty.

Systematic problem - like the device might not be calibrated (set to zero properly). The metal itself may not be pure aluminum - oxidization for example.

Precision - If all measurements have some uncertainty we show this by limiting the number of digits we use for that measurement.

eg. if you measure the length of a block using a ruler to be exactly 5 cm, the best you can say is that the block is 5.00cm because the smallest division on the ruler is a millimeter, so the last digit has the uncertainty.
You can't write it as 5.000000 because past the mm you are guessing, and 5.000000 implies precision to the millionth of a cm.

You shouldn't write it as 5 cm either, as this implies that it could be 6 or it could be 4. A large range.

We call the number of digits the significant digits or significant figures or sig figs.

Rules for sig figs:

Big Idea: sig figs imply the uncertainty.
no uncertainty = infinite sig figs
like pi or converting units cm is exactly 1/100 of a m

counting sig figs - change the number into scientific notation, and see the number of digits

eg. $0.532 = 5.32 \times 10^{-1}$

3

0.532 has 3 sig figs

rule: zeros at the start don't count.

0.0000002 has 1 sig fig

503.2 = 5.032×10^2 has 4 sig figs

4

rule: zeros between sig figs are significant

0.500 has 5.00×10^{-1} so it has 3 sig figs

rule: zeros after a sig fig and after the decimal count

5000 has (Chem) 1 sig fig always
but in physics, you should know it is unclear

in the textbook sometimes there will be problems that they say "you are driving at 100 km/h" and they mean 3 sig figs.

Lab: always write in scientific notation so it is clear.
test or quiz: I will try to make it clear but if it is unclear ask.

Rule for multiplying and diving values:

round your answer to the least number of sig figs of what you start with.

eg. 2.0 x 3.11 = 6.22 = 6.2 round to 2 sig figs

2 3

Rule for adding and subtracting:

Round the answer to the least number of decimal places. (same units and power)

eg. 32.5 km - 31 405m = ?

least

32.5 km
- 31.405km
= 32.5-31.405=1.095 = 1.1km

1.0500000001 or above round up to 1.1
1.0499999999 or below round down to 1.0
if 1.05 exactly round to the even = 1.0
but if it is 1.15 round up to 1.2